

DOE FIELD VERIFICATION PROGRAM FOR SMALL WIND TURBINES

Site Location: Spanish Fork, Utah

Quarterly Report for the Period January 1 – March 31, 2000

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Summary

During the second quarter of this project the Whisper 900 turbine in Spanish Fork, Utah, and the second turbine at the NREL/NWTC were both brought online with complete data acquisition systems operational. Since monitoring of the turbine in Spanish Fork began, it has operated with 99.3% availability. The downtime was all related to testing operations, not faults in the turbine system.

Technical Issues

None

Management Issues

None

Action Items

None

Introduction

Windward Engineering has a Cooperative Agreement with the Department of Energy to install two Whisper 900 wind turbines, one at the NREL National Wind Technology Center and one at a test site near Spanish Fork, Utah. We will monitor the turbine in Spanish Fork for approximately three years and report energy production, availability, and general operating experience. In addition, we will create a computer model to predict the furling behavior of the Whisper 900. We will compare the predictions with measurements from the Utah test site.

This is the second quarterly report on this project. We will discuss progress in each task area (according to the contract Statement of Work) in the paragraphs that follow. A summary of test results follows the Task descriptions.

Task 1. Install two turbines and repair as needed

The turbine in Spanish Fork, UT and the turbine at the NREL/NWTC are installed and operating with no known problems. This task is completed unless we encounter problems with the turbine systems that must be repaired.

Task 2. Phase I testing and analysis

This task has been the focus of our activity this quarter. The NRG data acquisition system is operational and we are collecting continuous data. A summary and discussion of test results to date is presented near the end of this report. We have measured many of the turbine mass and geometric properties for input to the computer models, but we have not finished the turbine characterization or the ADAMS model.

We have made significant changes to our web site. We have several photographs of the Whisper systems in Spanish Fork and at NREL. The address is www.windwardengineering.com.

Task 3. Phase II testing and analysis

In this task we will continue to monitor the turbine performance for approximately one year after the completion of Task 2, though at a less intensive level than in Task 2. No work was planned or completed in this task area during the current quarter.

Task 4. Phase III testing and analysis

In this task we will continue to monitor the turbine performance until the end of the contract, though at a less intensive level than in Task 3. No work was planned or completed in this task area during the current quarter.

Task 5. Turbine removal and inspection

No work was planned or completed in this task area during the current quarter.

Task 6. Reporting and Administration

The project has been proceeding smoothly with no particular problems to report.

Test Results

On February 26, 2000, the complete data acquisition system (DAS) became operational. We monitored the turbine with the NRG data logger prior to February 26, but we lost some segments of data due to unfamiliarity with the DAS. More important, we decided to monitor turbine energy production in addition to energy delivered to the grid from the inverter. We located a second energy meter a few feet from the battery bank and inverter. It measures energy delivered from the turbine to the batteries and inverter. It was installed on February 26. The original energy meter is located at the output of the inverter to monitor total energy delivered to the grid. We are reporting results from the date that both meters were operational to make the energy totals meaningful. It is interesting to note that the inverter delivers about 30% less energy to the grid than the turbine delivers to the batteries and inverter.

The tables and figures that follow are largely self explanatory. Note that we report the measured power data. The power curves are not corrected for air density, which was 12% less than standard sea-level density for the period of measurement. All wind speeds reported herein are the average of the two values measured by the primary anemometer (at hub height + the rotor radius) and the secondary anemometer (at hub height - the rotor radius).

Table 1. Project Information and Summary

Reporting period: Jan. 1, 2000 through Mar. 31, 2000

Project configuration	
Turbine(s) Installed	1
Turbine Serial No(s).	4302281
Rated Capacity/Rated Speed, kW/m/s	0.9kW/12.5m/s = 0.072
Turbine Hub Height, ft/meter	30.5 ft
Rotor Diameter, ft/meter	7 ft
Date Turbine(s) Commissioned	Jan. 25, 2000
Date DAS Commissioned	Feb. 26, 2000
DAS Manufacturer & Model Name	NRG 9300SA
DAS Scanning Rate	1 Hz
Data Averaging Interval	10 min.

Performance Statistics	Quarterly
Total Hours in the Quarter*	821
Wind Turbine System Availability*, %	100%
DAS Availability*, %	99.3%
Total Wind Turbine System Energy, kWh	102
Energy sold to utility grid (through inverter), kWh	72
Average Hub Height Wind Speed, m/s	4.6
Average Temperature (Degree C)	6.9
Average Air Density (kg/m ³)	1.078
Average Air Density Percent of Standard Atm., %	88%

*Availability numbers and quarter hours are for the period since the DAS commissioned not from the start of the quarter.

Unusual Occurrence Report:

None

Table 2. Calibration of all Instrumentation

The calibration of all instrumentation should be done and reported **annually**.
Changes and re-calibration within the year should be reported **quarterly**.

Instrument	Manufacturer	Model Number	Serial Number	Calibration Date	Calibration Due Date	Day Remaining
Anemometer, Primary	NRG	#40 Max	stock item*	11/04/1999	11/04/2000	214
Anemometer, Secondary	NRG	#40 Max	stock item*	11/04/1999	11/04/2000	214
Power Transducer	Flex-core	P-142X5-Y39	9111128	11/18/1999	11/18/2000	228
Power Integrator	Flex-core	PA-007/18k-G	21300	02/21/2000	03/21/2001	351
Wind Direction Vane	NRG	#200P	stock item*	11/04/1999	11/04/2000	214
Frequency Transducer	Flex-core	FTA-00202X5	9111031	11/18/1999	11/18/2000	228
Availability Sensor (switch)	Windward Engineering	None	built on site	NA	NA	NA
Data Logger	NRG	9300	93001081	11/04/1999	11/04/2000	214
Temperature Sensor	NRG	110S	stock item*	11/04/1999	11/04/2000	214
Barometer Sensor	NRG	BP-20	18051143	11/01/1999	11/01/2000	211

*Stock item represents that the item did not come with a unique serial number.

Table 3. Project Summary

Reporting Periods:

1

Quarterly Summary								
SWT #	kWh Total	kWh/m ²	Capacity Factor****	Unavailable Hours*	Turbine Availability	Max. Watt**	Concurrent Wind Speed***	Ave. Wind Speed at Hub Height
1	102	28.5	11%	5.5	99.3%	708	11.7	4.63

* Unavailable hours events are shown in Table 4 and include data from the DAS system and from site operation log sheets;

** maximum power is the peak 10-minute-average output.

*** The concurrent wind speed is a 10-minute average wind speed

****Rated output is 900watt

Table 4. Unavailable Time Events Summary

Reporting Periods:

1

Table 4a. Unavailable Time Events

SWT	Event Start, d/t	Event Stop, d/t	hr. Down	kWh lost*	Cause
1	03/07/2000 10:20	03/07/2000 11:40	1.5	0	lowered tower to adjust guy wires
1	03/07/2000 16:30	03/07/2000 16:30	0.2	0	DAS momentarily down
1	03/07/2000 17:00	03/07/2000 17:20	0.5	0	lowered tower to adjust guy wires
1	03/10/2000 15:10	03/10/2000 16:20	1.3	0	lowered tower to measure hub for dynamometer mount
1	03/13/2000 15:40	03/13/2000 17:30	2.0	0	lowered tower to measure hub for dynamometer mount
Total Unavailable Time and Lost Energy			5.5	0.0	

* Estimated from the measured power curve

Table 4b. Unavailable Time Summary by Type

Category	Hours	Lost Energy, kWh	Remarks
Fault: Wind Turbine			
Fault: Inverter			
O&M	2.0	0.0	lowered tower to adjust guy wires
Turbine measurements (related to modeling)	3.3	0.0	lowered tower to measure hub for dynamometer mount
Ground Testing (related to modeling)			
Instrumentation installation or calibration			
DAS disable	0.2	0.0	DAS momentarily down
Host site system disable			
Battery over voltage			
Blown fuse			
Brake cooling cycle			
Inverter faults			
Unknown			
Others			
Total	5.5	0.0	

Figure 1.
Distribution of Quarterly Average Wind Speed
(Spanish Fork, UT Test Site)

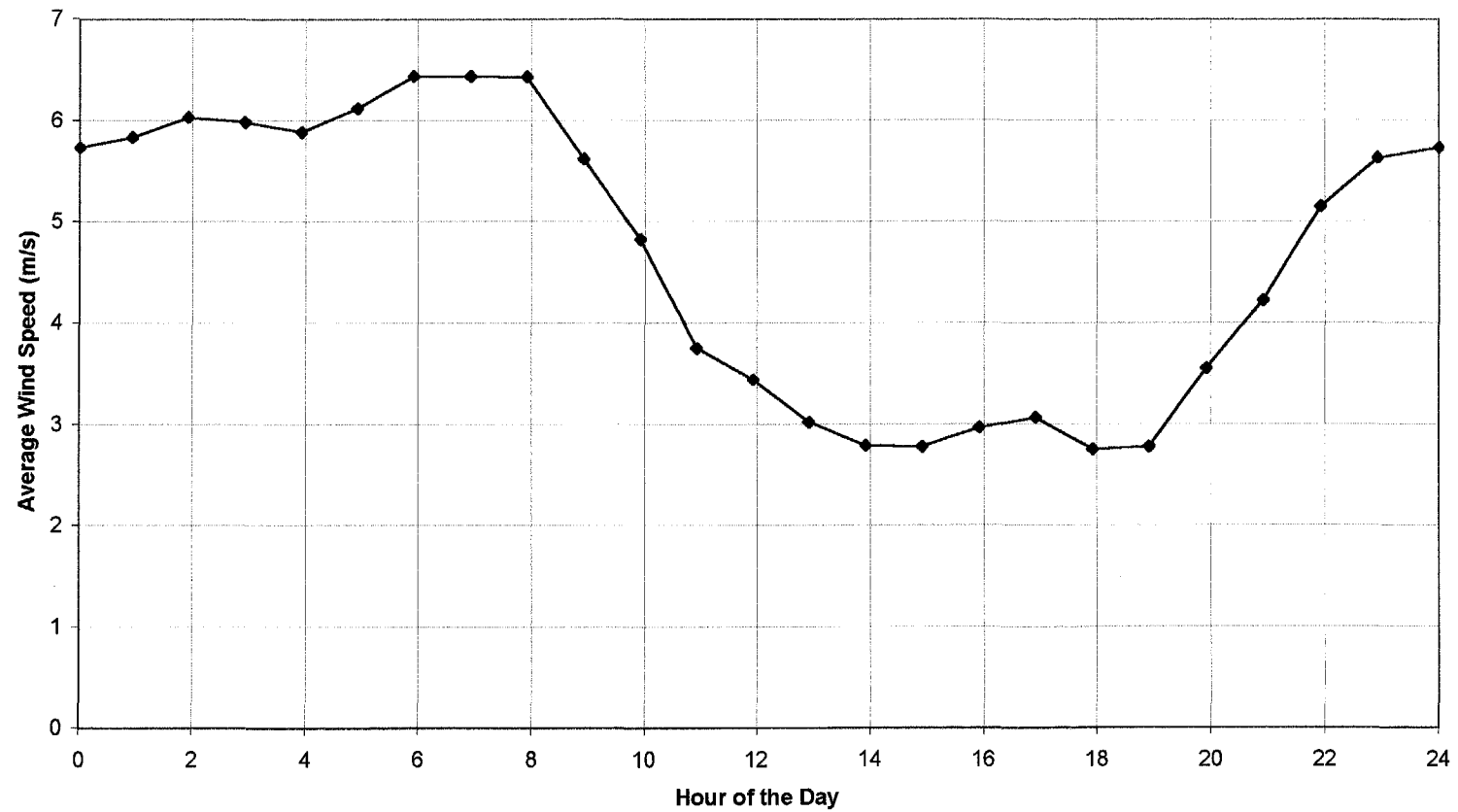


Figure 2.
Distribution of Quarterly Energy Output
(Spanish Fork, UT Test Site)

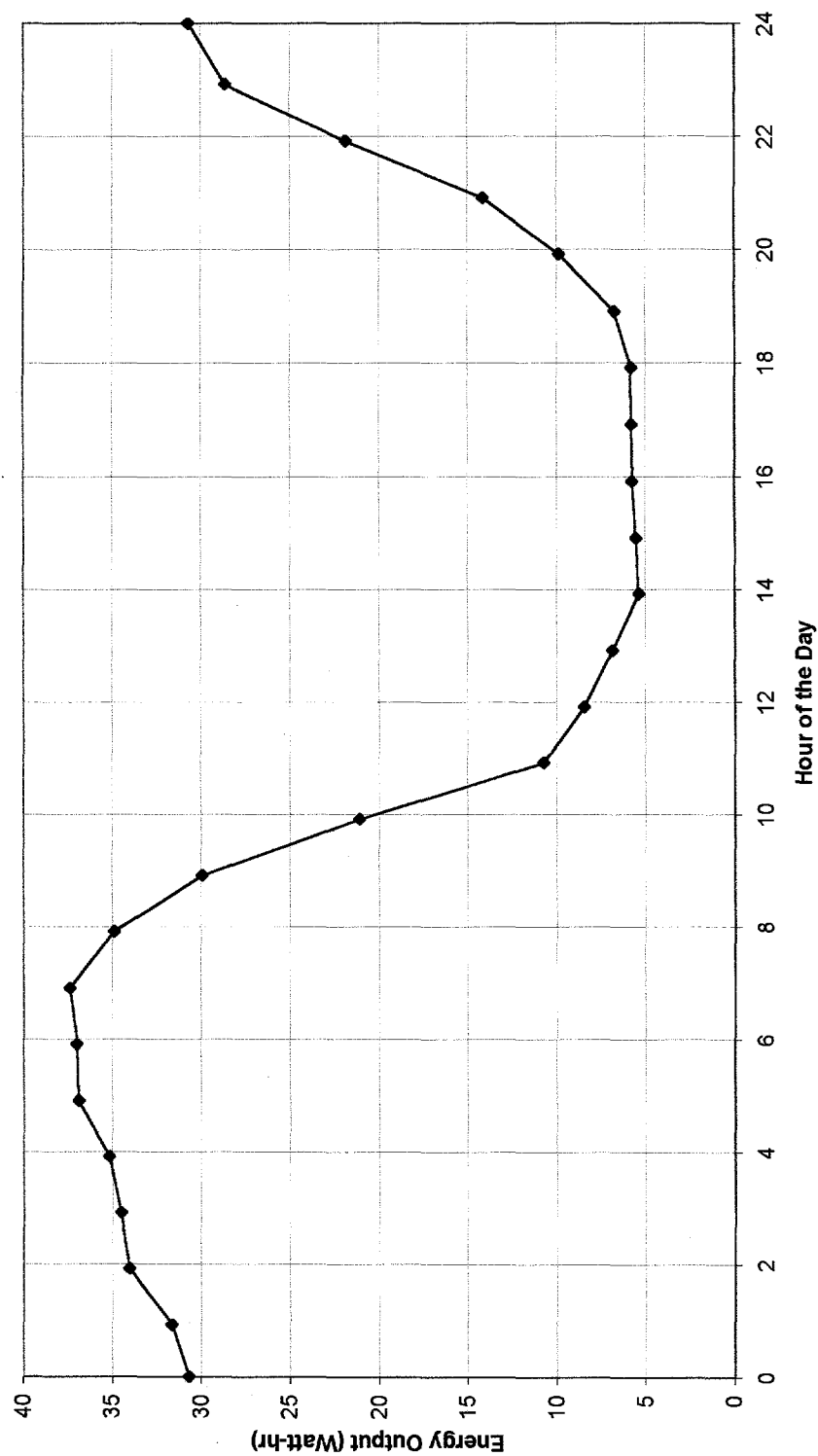


Figure 3.
 Ave. System Availability - World Power Technologies - Whisper H900
 (Spanish Fork, UT Test Site)

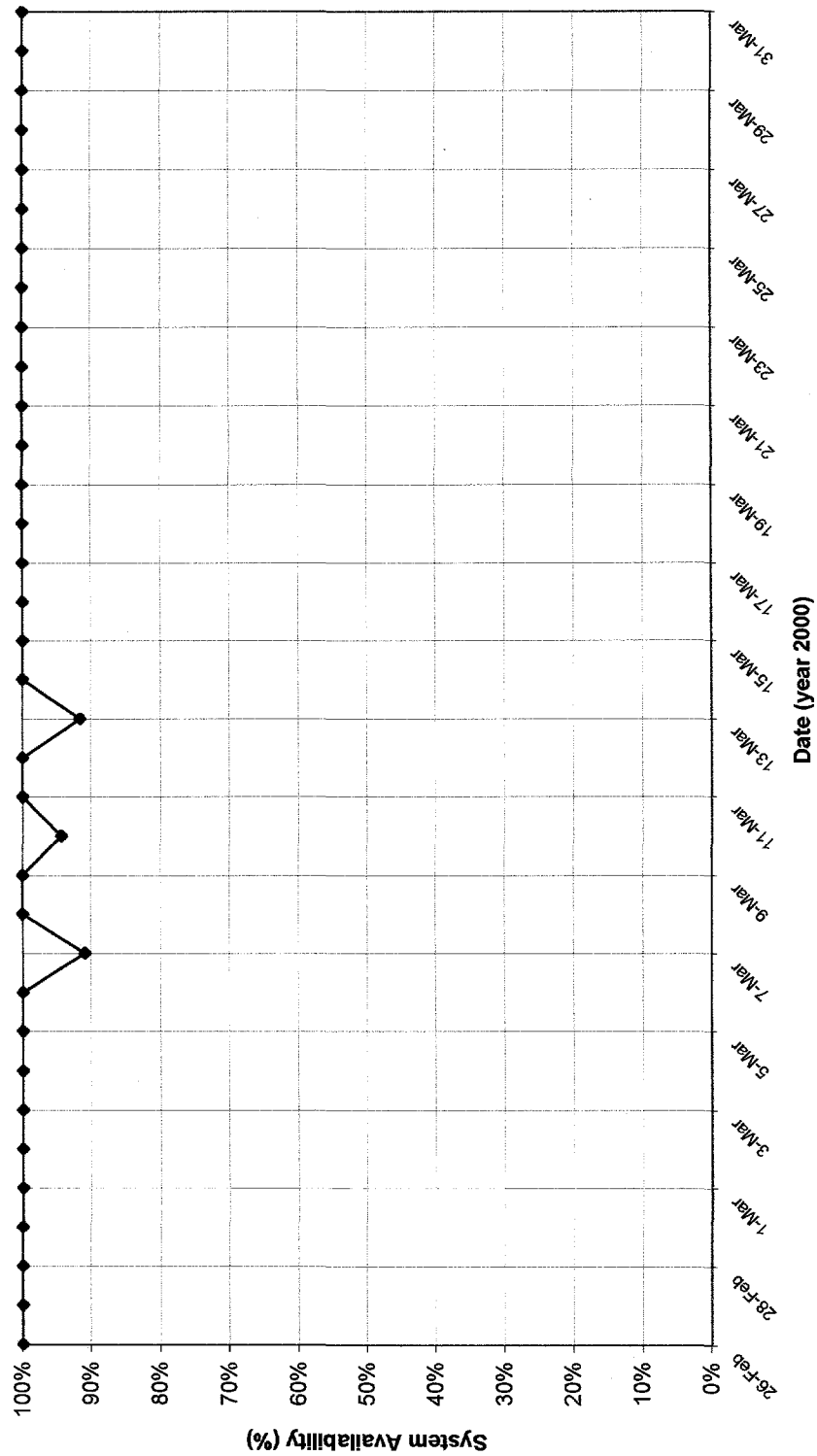
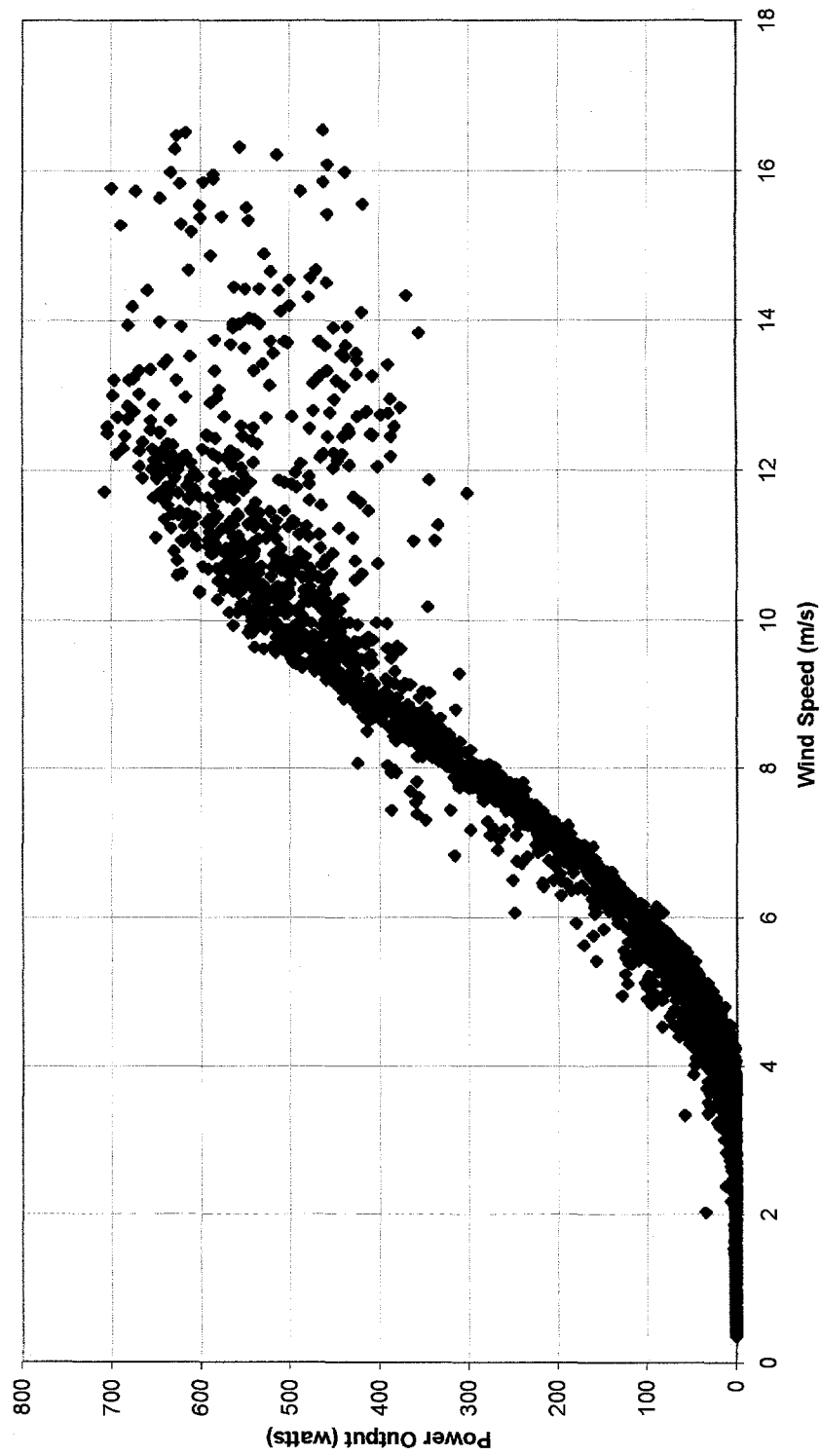
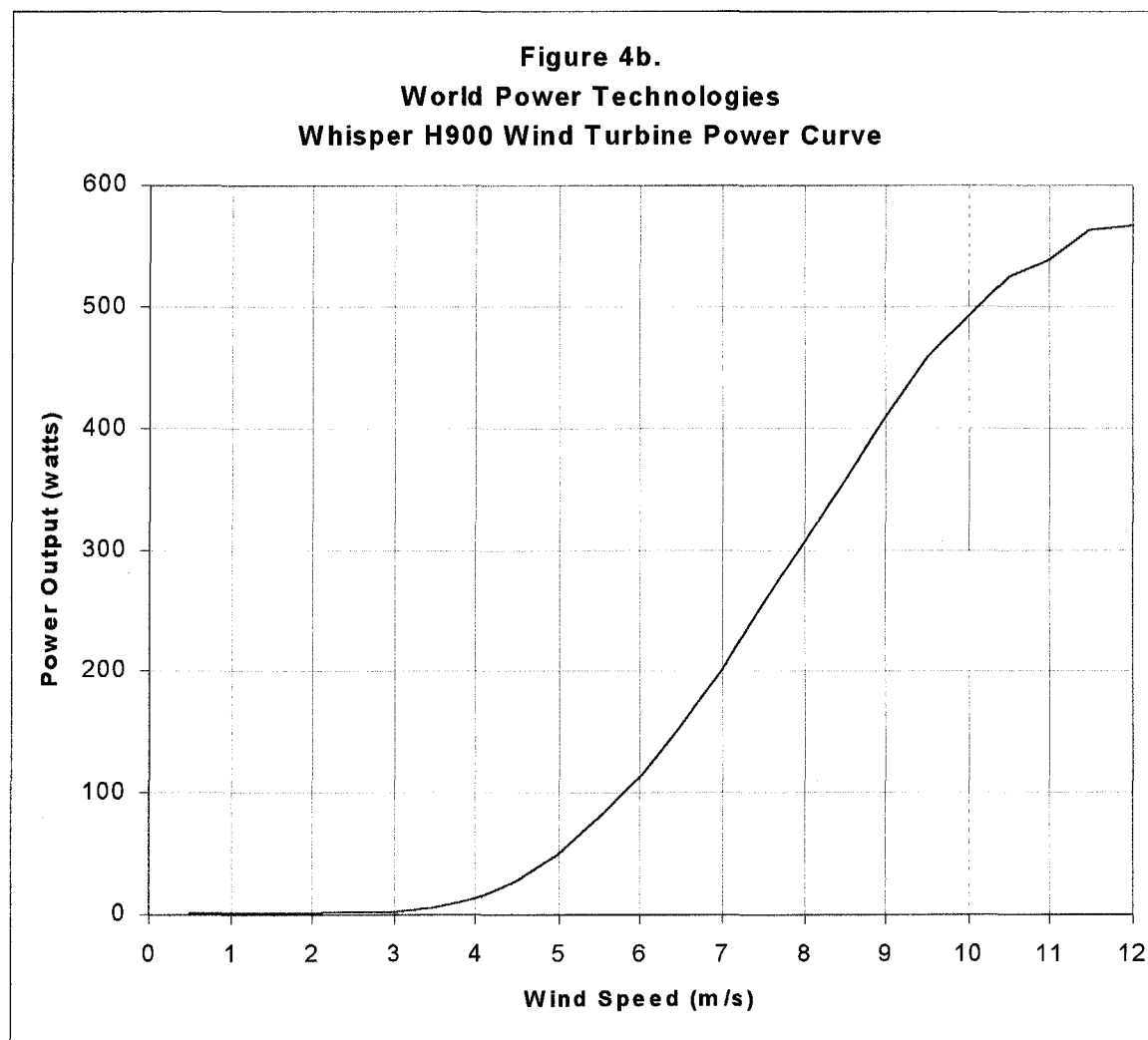


Figure 4a.
World Power Technologies
Whisper H900 Wind Turbine Power Curve Scatterplot





Wind Speed	Power
(m/s)	(watts)
0.5	1.6
1.0	1.7
1.5	1.7
2.0	1.8
2.5	2.0
3.0	2.6
3.5	6.4
4.0	14.2
4.5	27.7
5.0	49.2
5.5	80.2
6.0	115.1
6.5	156.3
7.0	201.0
7.5	257.2
8.0	303.9
8.5	355.7
9.0	409.7
9.5	459.4
10.0	492.9
10.5	524.2
11.0	538.1
11.5	562.4
12.0	566.9